



ANALYSIS OF ECG SIGNALS PROCESSING FOR SMART MEDICAL TECHNOLOGIES

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Abstract

The human body is constantly producing signals or information that have valuable health information. These signals must be taken from the body and processed to diagnose the disease. Using this information, blood pressure, hemoglobin level in the blood, brain activity, heart activity, etc. can be measured invasively and non-invasively. The signal received from the human body contains noise and it has low amplitude data that cannot be directly used for diagnostic purposes. To be useful, the signal must be filtered to remove noise and amplified to obtain accurate information. Signal processing plays a major role in medical technology in the diagnosis and treatment of disease. In this review, the application of signal processing, particularly in ECG medical technology, is considered. Methods and algorithms for eliminating ECG noise are briefly discussed. Improvements in these technologies to improve human health are also discussed.

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1. INTRODUCTION

The growth of the elderly population is expected to reach 56% by 2030 and double by 2050. There have been significant improvements in medical technology that produce data such as electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), neural functions, and biomarkers to improve medical services for them. The human body is a storehouse of valuable information about organs and cells. The obtained data cannot be directly used by clinicians to diagnose the disease. For a raw signal to be useful to clinicians, it must be processed and converted into biomedical signals that can be analyzed and read by clinicians. Biomedical signal processing is the raw material from the human body. the method used to

process the data so that it can be read. Therefore, significant advances in signal processing, especially in medical technology, began to grow. Engineers and researchers around the world are developing new algorithms, components and measurement techniques to upgrade from invasive to non-invasive methods that can collect health details without piercing the body. Biomedical signal processing includes four main steps: signal reception, signal digitization, signal computation, and signal interpretation. Biological signals can be divided into two large groups as stochastic and deterministic. Stochastic signals are divided into stationary and non-stationary signals, and deterministic signals are periodic, divided into three types such as transient and quasi-periodic signals. Biomedical signals are more useful for systems engineers in modeling bioelectrical and mechanical systems. Although existing signal processing tools are highly efficient for signal detection and processing, there is still much progress to be made in this field for human cognition. Biomedical signals can be divided into two types as action potential and event-related potential signals. ECG, EEG, and EMG are action potentials, speech signals, phonocardiogram (PCG), catheter tip sensor signals, and other signals such as vibration. Arthrogram (VAG) is classified as event-related potentials. Among the applications mentioned above, ECG signals are mainly used for cardiovascular problems, sleep apnea, used to diagnose many applications such as emotional and arrhythmia detection. The ECG signal consists of PQRST waveforms, which can be divided into P wave, QRS complex, T wave, and U wave. Most ECG measurements require cleaning to obtain accurate data and signal processing to provide authentic ECG signals. In addition, many imaging modalities such as ultrasound, functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and computed tomography (CT) have been used in medical signal processing. These imaging techniques have been used to diagnose diseases such as cancer, tumors, and brain activity. High-spatial-resolution functional information generated by fMRI the data can be used to analyze the brain's performance in different conditions. It can be used to classify epileptic seizures and is designed to detect changes in brain activity. Along with EEG, fMRI has been used to study and investigate pain in the diagnosis of sickle cell disease. Computed tomography is a non-invasive procedure used to study the anatomy of the heart with high resolution.

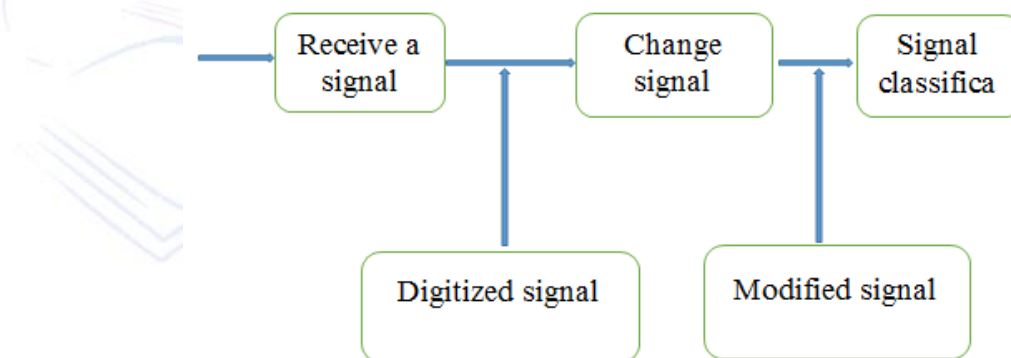


Figure 1: Block diagram of biomedical signal processing.

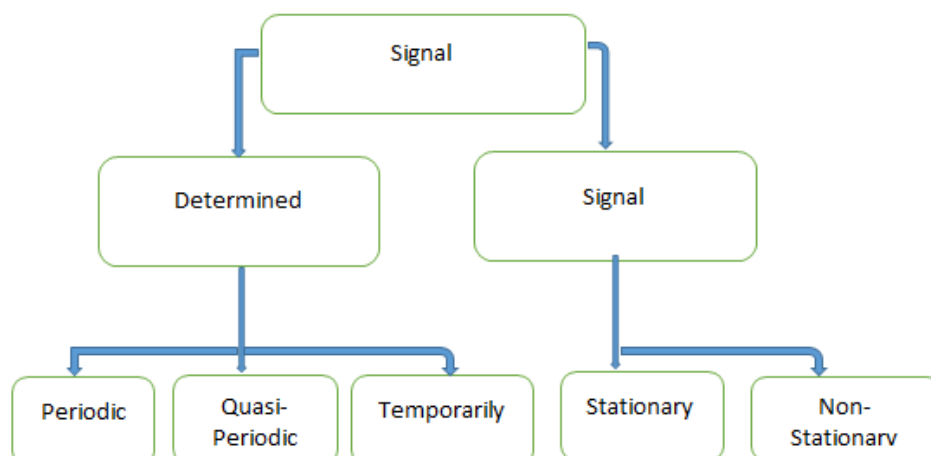


Figure 2: Classification of signals.

3D ultrasound imaging techniques are used to examine pathology and complex anatomy. Recently, this method can be used in fetal measurements and nerve movements. It has successfully demonstrated segmentation and nerve detection using ultrasound imaging techniques. All the imaging techniques discussed above have been used in various diagnoses such as breast cancer, ventricular tachycardia, malignant rhabdoid tumor, and atrial fibrillation. Although image processing is widely used in medical applications, signal processing also plays a major role in medical applications compared to image processing techniques. This review examines in detail the role of signal processing in the field of medical technology. Noises in ECG signal processing and noise elimination methods are briefly discussed. The importance of signal processing in ECG and FEKG processing was also discussed.

2. IN MEDICAL TECHNOLOGIES

ECG Signal Processing An ECG is a simple, non-invasive measurement that can be used to determine the activity of the human heart. For each heartbeat, an electrical signal from the heart is transmitted throughout the body. These signals can be measured using electrodes that pick up the microvolt signal and transmit it to the processing system. In the signal processing unit, the received signal is passed through a pre-amplifier and passed through a filter to remove unwanted noise, then it is passed through a post-amplifier to improve the continuity of the signal to interpret the information from the signal.

2.1. ECG interference and external influences

ECG noise can be divided into three categories: baseline and abrupt drift (BWAD), electrical conduction interference (PLI), and muscle artifacts (EMG). BWAD is caused by skin-electrode impedance, breathing, poor electrode contact, and body movements. These factors determine the duration and peak amplitude of BWAD. BWAD increases when the ECG is recorded under stress, which increases the respiratory rate. PLI is related to the inductive and capacitive connections of the power lines in the ECG circuit. Low frequency components present in PLI are mixed with ECG signals and distort the whole ECG signal. These noises can distort the amplitude and shape of the ECG signals. EMG is caused by muscle movements during EKG measurements. ECG signals were very sensitive to muscle movements and were distorted when the subject moved during the measurement. These muscle artifacts have been reported to significantly distort and bias the ECG signal.

2.2. Signal processing in ECG measurements

Recent studies show that existing ECG processing systems produce unreliable and inaccurate measurements that lead to distorted and noisy ECG signals. This noisy signal leads to false diagnosis of heart problems. The current ECG processing system cannot distinguish between noise, artifacts and real ECG signals. Thus, to obtain a truly accurate ECG signal, these noises must be removed or filtered using special signal processing schemes before signal processing. Several methods have been developed to solve this problem. In addition, a strategy based on ECG loss and a strategy based on signal quality index (SQI) are of interest to extract the real ECG signal. Many ECG denoising techniques have been reported to remove and eliminate the noise present in the ECG signals. Adaptive filters, EMD-wavelet method, median filters, empirical mode decomposition (EMD), non-local means method, singular value decomposition (SVD), frequency selection filters, independent component analysis (ICA), discrete cosine transform (DCT), Wiener filters and nonlinear Bayesian filters are of research interest. These denoising methods are highly adapted to remove noise and artifacts that differ from the ECG signal pattern. However, these results suggest that these methods may distort the ST segment due to the attenuation of low-frequency components. Further studies have shown that simple filters are not sufficient to eliminate noise due to artifacts without distorting the real ECG signals. Reports show that the main distortion is caused by EMD-based denoising techniques at the beginning and end of the QRS complex. Some studies have shown that severe artifacts caused by object motion cannot be removed using linear filters. Also, some papers have reported that most of the denoising methods significantly change the local ECG waveforms due to problems with ECG noise and artifacts. Although it has advantages, it cannot satisfy the consumer's need for ECG signal processing. And so,

SQI-based methods were used to overcome the problem caused by EMD-based denoising techniques. Various signal quality assessment (SQA) techniques have been reported to address the noise problem and improve the quality of ECG signals. A wide range of SQIs were calculated for the raw ECG signals and combined to remove spurious ECG signals. SQA methods can be divided into five main categories, such as:

- 1) reliable features and SQA methods based on machine learning;
- 2) SQA methods based on reliable properties and heuristic rules;
- 3) SQA methods based on non-fiducial properties and heuristic rules;
- 4) non-reliable features and SQA methods based on machine learning;
- 5) SQA methods based on filtering. In all methods, initially, the signal is pre-processed to filter the noise using digital filters and decomposition methods. Next, extraction is done to get the ECG signal or noise, and finally, the signal is divided into groups based on signal quality, which can be achieved using machine learning techniques and artificial intelligence. Signal quality indices (SQIs) for the measurement of clear hearing rates were reported by Orphanidou et al. Using template matching and heartbeat features, signal quality was determined. They tested this method based on PICC and ambulatory ECG recordings. It was found that this method can be used to determine the exact QRS during movement. Detection of myocardial ischemia using real-time ambulatory ECG signals has been reported. This method was tested taking into account motion artifacts and a noise stress database. The results obtained from the method show that its efficiency is 0.89 for correct classification of signals. It is also observed that this method can give good results with PQRST signals and heart rate changes. Johannesen et al reported a two-step algorithm in which lead-absence and amplitude-shift errors are first eliminated from the ECG signals and eliminate ECG noise. The spline function artifacts along with the high-pass filter in the design, used to detect and remove noise due to power lines and mains. An accuracy of 92.3% and 90% was obtained from the train set and the test set, respectively. Analysis of ECG signals using a modified Tomkin detection algorithm was performed by tat et al. After processing the signals from the algorithm, a group of threshold rules were used to remove the noise from the ECG signals. The message method has a 92% SQA result. Hein et al. presented a signal processing algorithm to improve its quality. Based on this algorithm, applications designed to analyze ECG signals on a mobile phone using simple signal quality characteristics have been created. The reported algorithm has high efficiency compared to existing methods.

3. RESULT AND ANALYSIS

Although many articles and studies have been reported on ECG noise cancellation to obtain a clear ECG signal under various conditions, such as movement, rest, and ambulatory, many improvements are still needed. Many methods are aimed at eliminating spurious signals and several methods are aimed at extracting ECG signals. In addition, all methods focus on performance evaluation based on accuracy and reliability, not just energy efficiency. Power consumption is also one of the main factors to consider when reading ECG signals on a handheld device. Therefore, signal processing research, the application of ECG in medical technology is still energy intensive.

Table 1. Comparison of the effectiveness of different methods of processing the ECG signal

Signal	Event detection	Work	Information
ECG and PPG	R-peak	Good	30
EKG	QRS complex	Good	31
EKG	Form PQRST	Clean/Contaminated	32
EKG	QRS complex	ROC analysis	33
EKG	QRS complex	Good/Bad	34
EKG	QRS complex	Good/Bad	35
EKG	QRS complex	Classification by spectrum	36

4. CONCLUSION

The increasing number of heart-related problems has forced people to regularly monitor their heart function. In a busy life, it is difficult to visit hospitals and laboratories every day to monitor their health. Many technological innovations help people take care of their health with the help of convenient devices. Signal processing plays an important role in this, helping to transform raw data into something understandable. This review specifically discussed the role of signal processing in ECG applications. ECG noises and their characteristics were discussed. also

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